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Preven-T

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PREVEN-T Project Profile

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Partners

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	Military Academy "General Mihailo Apostolski" (MAGMA)	RNM
	National Park Pelister	RNM

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Abbreviations and acronyms

Deliverable	D
Expected Outcomes	EO
International Hellenic University	IHU
Non-governmental organization	NGO
Land Use Land Cover	LULC

Executive Summary

PREVEN-T is a 18 month duration project funding from the Interreg IPA Cross-border Cooperation Programme: PREVEN-T – CN2 – SO2.4 – SC049.

The overarching objective of the PREVEN-T project is to improve the operational efficiency and the administrative capacity of relevant services in natural disasters management. At the same time project's goal is to enable education, awareness and sensitization of the local population, so that in cooperation with the competent authorities to have a coordinated action to deal with Natural and Technological Disasters and Risks.

The main purpose of this document is to investigate the diachronic vegetation changes, since the early 1980s, in the Pelister NP using multitemporal landsat data. The specific objectives are a) to investigate the degree of vegetation densening and loss of open habitats using a number of vegetation indices which are often employed for long term monitoring and b) to discuss the observed changes in relation to implications on fire risk.

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1 Introduction

1.1 Purpose of the document and background

Pelister NP is not considered a typical fire prone area, similar to the ones observed in the Mediterranean region. However, in recent years several publications demonstrate a significant change in fire behaviour with its area of distribution being constantly expanding at higher altitudes and latitudes. This trend has been attributed to two major drivers. The increase of vegetation cover due to agricultural land abandonment and urbanisation and the observed climatic trends of increased summer temperature and decreased summer precipitation leading to increased drought conditions during summer. The purpose of this document is to investigate the diachronic vegetation changes, since the early 1980s, in the Pelister NP using multitemporal landsat data. The specific objectives are a) to investigate the degree of vegetation densening and loss of open habitats using a number of vegetation indices which are often employed for long term monitoring and b) to discuss the observed changes in relation to implications on fire risk.

1.2 Intended audience

The intended audience of this document consists of the following target groups:

- PREVEN-T project partners and the Project Officer at the Managing Authority
- Land managers and practitioners in Pelister National Park

1.3 Work Package Objective

The current technical report refers to WP3.1 where its main objective is the Monitoring of forest, early detection of forest fires, warning of relevant institutions for dealing with forest fires and spread forecasting systems since all of them are very important part of the circles of dealing with forest fires.

1.4 Structure of the document

In chapter 2, this report describes the applied methodology for the current research conducted in Pelister National Park using remote sensing and methodologies and in situ observations

In chapter 3, this report presents the results achieved from the current research.

In chapter 4, this report discusses the results in relation to the elevated risk of wildfires due to the increase in biomass and vegetation cover.

2 Research aims and methodology

2.1 Research aims

The outbreak of the Industrial Revolution in Europe in the 19th century signified the beginning of two very important changes in Western societies. The urbanization of the population and the intensification of production, whether it concerned the new-ly-entered industrial production or agricultural and pastoral production [1]. The combination of these two factors gradually intensified, in the early 20th century. The abandonment of mountainous and semi-mountainous areas and the establishment of these populations in cities and urban areas allowed the intensification of agriculture and stock breeding and production increase [2]. This phenomenon was further intensified during the second half of the 20th century and reached the decade 1990 - 2000 involving the abandonment of 20 Mha in 20 European countries, marking significant changes in land cover and use [3]. This Land Use/Land Cover (LULC) change has increased the extent of forests in Europe by 9% in the last 30 years. Approximately 227 Mha, more than the third of Europe's land, is now forested [4]. The Republic of North Macedonia had a different sociopolitical status, compared to western European countries, which may have prevented or delayed the landscape changes described above. As a result it is important to investigate the landscape dynamics of the study area in order to asses the potential risk of fire or other natural disasters related to the landscape structure and composition.

Land abandonment is considered as one of the main drivers of LULC changes with sig-nificant environmental and socio-economic implications which can be positive or neg-ative, depending on local factors and conservation objectives [5]. Recovery of forests can reduce soil erosion, increase biodiversity and create carbon reservoirs [6]. How-ever, it can also lead to the reduction of many semi-natural, open habitats previously maintained by traditional land management, causing a significant impact on the land-scape, biodiversity, ecosystem, dynamics and sustainability of mountainous landscapes [7].

Keenleyside and Tucker [8] reported that, in some cases, the re-colonization of plants and the disappearance of open spaces endanger semi-natural habitats by causing reduced biodiversity. However, in other cases, abandonment can be beneficial as it helps to restore natural habitats, especially in landscapes that are highly fragmented by human activity [9]. Consequently, systematic monitoring and detailed recording of LULC change and trends is becoming increasingly necessary, both for economic and environmental reasons, as they can be key indicators of environmental / ecological change at different spatial and temporal scales [10]. Monitoring land use changes with time and cost efficient manners is essential for reducing biodiversity loss and for implementing Streamlining European Biodiversity Indicators 2020 (SEBI 2020) [11] and for forest fire prevention.

Recent advances in remote sensing data availability, quality and methods offer a great tool for the long term monitoring of LULC trends [12]. Remote sensing data, covering a wide part of the electromagnetic spectrum, including near and short-wave infrared channels, allow the calculation of a large number of vegetation indices. The latter, are designed to enhance the vegetation signal to allow reliable spatial and temporal comparisons of terrestrial photosynthetic activity and canopy cover [13].

In recent decades, LULC monitoring using remote sensing data has significantly improved spatial and thematic accuracy of the resulted products, mainly because of the development of new technologies and applications along with appropriate algorithms for data analysis. Crucial in this area is NASA's Landsat program, which, since 1972, has provided the repetitive acquisition of multi-spectral, high-resolution Earth Observation data on a global basis leading to the largest database of the Earth's surface [14-19]. The release of the program data for public use free of charge, through the Earth Resources Observation and Science (EROS) center made possible to easily access an unprecedented volume of data, opening new horizons in the detection of changes on the earth's surface [20].

The aim of this research is to investigate the diachronic vegetation changes, since the early 1980s, in the Pelister NP using multitemporal landsat data. The specific objectives are a) to investigate the degree of vegetation densening and loss of open habitats using a number of vegetation indices which are often employed for long term monitoring and b) to discuss the observed changes in relation to implications on fire risk.

2.2 Methodological framework

2.2.1. Study area

Pelister National Park covers relatively small area (18.845 ha) on the northern side of the Baba Mountain massif, in the south-western part of North Macedonia, at altitude of 891 to 2601 m. The territory of the Park includes various glacial and periglacial geomorphological formations, some of which are rare in the Balkans, preserved in their natural state and of high attractiveness to Park' visitors. Because of the geological composition, specific terrain and the local mountain climate, various habitat types have been formed in the Park supporting rich and important biological diversity. Of these the most prominent are the extensive forests of the Balkan Pine (*Pinus peuce*) the most important habitat of its type in the Balkans and therefore in the World, the glacial lakes and the alpine grasslands. In addition to the nine local endemics – species that can only be found in the Park's territory – there are also several rare and/or threatened species. In addition to the natural, within the territory of Pelister National Park there are also numerous cultural values among which the architectural and cultural heritage of the village Malovishta stands out.

2.2.2. Climate

The climate of the south-western part of North Macedonia where Pelister Mountain is located can be characterized as moderate continental. However, because Pelister National Park is situated at altitudes higher than 900 m its local climate is typically mountainous. The winters are long, cold and with lots of snowfalls, whereas the summers are short and rather cold. January and February are the coldest months whereas July and August are the warmest. The precipitation is highest in October and December, but there is another peak in May. The precipitation during the summer season accounts for 16.5% of the annual amount. The snow cover stays from November to April, in the higher parts to May, and in small remnants up to

June. The data on precipitation levels and temperature in Pelister National Park are available only for the period from 1934 to 1940 when there was a weather station in the Park.

2.2.3. Geology

The bedrock in Pelister National Park is primarily Paleozoic and Mesozoic in age, with few glacial and fluvioglacial overlays dating from Quaternary. Among the Paleozoic rocks, the series of green shale are the oldest and most ubiquitous stratigraphic unit. Typical for the Park is the “Pelister Granite”, Paleozoic alkaline-granite dating from the Ordovician, some 456 millions years ago, and usually embedded within the Paleozoic shale. Other Paleozoic rocks found in the Park include quartz- and quartz-sericite schists. The gabbro is the most ubiquitous among the Mesozoic rocks, found in several places, including a large mass with a surface area of 5 km2, situated south-east of the village of Malovishta. Other Mesozoic complexes are also found, such as diabase and mermekitic granite and dolerite veins. Due to the nature and compactness of the bedrock as well as the vegetative cover and lack of human activities the erosion in the Park is negligible.

2.2.4. Geomorphology

The glacial landforms are an important part of the landscape in Pelister National Park. Within the boundaries of the Park there are three fine examples of cirque fields two of which contain lakes. The most spectacular is the cirque between the peak Veternica and the R’bet ridge, having north-east exposition, some 1.0 km in width and 1.6 km in length. In the westernmost part of the cirque, lays the Greater Lake. The second, the Smaller Lake, lays in the cirque situated between the peaks Shiroko Stapalo and Partizanski. During the Würm glaciation period the glaciers were hanging over the shoulders of Pelister Mountain. The block streams are most prominent among the periglacial landforms in Pelister National Park. They typically extend from above the forest margin down slope to 1.200 m above the sea level; some of them are more than 2 km in length and between 100 and 300 m wide. This feature is indicative of their high activity during the Pleistocene epoch (1.8 million to 8.000 years ago). Although the block streams in the Park are still active, many of them have been overgrown by the quickly expanding molika forest. To the north-east of the peak Pelister (2.601 m) and towards the peak Stiv (2.468 m) is found a typical block field – a periglacial form of frost-shattered granite blocks, scattered over a slightly bent area. Other glacial and periglacial landforms in the Park include nivation hollows, garlands, solifluction lobes, and ploughing blocks. The latter consist of Paleozoic alkaline granites and can be found on the eastern, north-eastern and the northern side of the massif. Typical examples of the ploughing blocks are found in the cirque of the Smaller Lake.

2.2.5. Soils

Through the interaction of the topography and climate in the Park, as well as the biological agents, there are three major soil types in the Park: (a) humic-silicate (rankers); (b) acid brown (cambisols); and (c) ilimerised (brunipodzols, brownised cambisols). Within the areas covered by forest, i.e. Balkan pine, beech and oak forests, the acid-brown soils prevail; several varieties and different evolutionary stages can be distinguished within these soils. The humicsilicate soils are found in the sub-alpine and the alpine zone and less frequently in the forest zone. The third soil type is found in the sub-alpine zone in places overgrown by molika trees.

2.2.6. Waters

The area of Pelister National Park is part of the river Crna watershed and includes two glacial lakes and seven rivers: Malovishka (Shemnica), Manastirska, Caparska, Rotinska, Magarevska, Crvena and Ezerska. The Greater Lake lies at 2.218 m altitude, elliptical in shape (3.7 ha), is 223 m long, 162 m wide and 14.5 m deep. The Smaller Lake lies at 2.180 m altitude, of irregular shape (0.66 ha), is 97 m in length, 68 in width and 2.6 m in depth. Groundwater in the Park feeds the numerous springs throughout its territory. There are also few intermittent surface water courses, mainly on the Prespa side of the Park.

2.2.7. Ecosystems and habitats

The geology and soils in an interaction with differences in altitude, temperature, rain and snowfall, but also the livestock grazing, contribute to the high variety of ecosystems in the park which in turn sustain a wide range of plant and animal life. All major types of ecosystems which are typical for Macedonia are also found in the Park: forests, dry grassland, mountain ecosystems and fresh-water ecosystems. The vegetation ranges from heat and scrubs through broadleaved deciduous (the oak and beech) and coniferous (molika pine) woodland to dry siliceous, alpine and sub-alpine grasslands, as well as riparian source edge grassland communities and aquatic habitats. There are thirty-two different natural habitat types in total the Park (see Table 1, Annex I in the Supplement of this Plan) nine of which are forest communities and sixteen grass communities. The systematic classification of the plantcommunities within the Park is shown in (see Table 2, Annex I in the Supplement of this Plan). Among these two are local endemic communities, that is, they can be found only in the Park, others have restricted distribution (parts of Macedonia or only in the Balkans), and nine are protected by the Bern Convention of the Council of Europe2 as habitats that require special conservation measures. It should be noticed that the number of habitat types in the park would be larger if the habitats which are created through human influence and interference as well as the habitats which are not described due to lack of data are added to the list.

Pelister National Park is widely known for its extensive Balkan pine forest. Balkan pine establishes two plant communities in the Park: the mountainous Balkan woodland (Digitali viridiflorae – Pinetum peuces), found between 900 and 1.600 m altitude, and the sub-alpine molika woodland (Gentiano luteae – Pinetum peuces) inhabiting its primary habitats between 1.500 and 2100 m altitude and higher in some places.

2.2.8. Fauna

The diversity of landforms and plant communities in Pelister National Park results in a wide range of wildlife habitats. The Park is especially important for its mammals, particularly the large predators, which their populations are decreasing or are threatened throughout Europe. There are forty-one mammal species registered in the Park, that is, one half of all mammal species registered in North Macedonia. It is important to notice the presence of the lesser mole rat (*Nannospalax leucodon*), which is considered to be a globally threatened species, and seven other species considered to be threatened in Europe. Several mammal species have been discovered and described for the first time by specimens collected in the Park: *Talpa stankovici, Clethrionomys glareolus makedonicus* and *Talpa caeca beaucournui*. Two species are considered rare and found only in some parts of the Balkans: *Talpa stankovici* and *Microtus felteni*. Twenty-four of the mammal species registered in the Park are protected by the Bern Convention. It should also be noticed that the bats (*Chiroptera*) in the Park are poorly investigated.

There are ninety-four bird species registered in the Park (30% of all bird species found in North Macedonia) out of which eighty-eight are protected by the Bern Convention, and twenty are protected by the Bonn Convention. Ten species in total are considered to be threatened in Europe.

Pelister National Park is an important refuge for ten amphibian species which represent 67% of all amphibian species in North Macedonia. Also, occurring in the Park are sixteen species of reptiles, that is, half of all know reptile species in North Macedonia. All amphibian and reptile species are protected by the Bern Convention. There is only one species of fish registered in the Park – *Salmo pelagonicus* (pelagonide trout) – a rare species with distribution in Pelister, Greece, Crete and some islands in the Aegean See, and considered to be threatened in Europe.

The invertebrate fauna is very rich and diverse, represented by more than 588 species and subspecies with many among them being found only in Baba Mountain. For instance, the amphipode species *Niphargus pancici pancici* can be found only in the mountain springs in Pelister and Baba massif. The group of freshwater crabs is insufficiently investigated and there are indications that the number of local endemic species may be higher. Among the insects the carabides are represented by eighty-seven species and subspecies, out of which six are local endemics. There is detailed information on other groups of invertebrate animals (*Curculionide, Ropalocera, Odonata, Orthoptera, Syrphidae, Chrionomidae, Chironomids, Aranea, Gastropoda, Diptera, Lepidoptera*, and others) among which there is a great number of Balkan endemics. On the other hand, some groups have not been investigated in the Park yet, such as *Heteroptera*, *Neuroptera*, *Hymenoptera*, *Plecoptera* and others.

2.2.9. Remote Sensing Data

Overall, more than 100 Landsat images (Path:185, Row:032) were downloaded from the EROS center and 38 of them were selected to build a time-series dataset covering a period of 35 years (Table 1). The rest were excluded from the analysis, either due to extensive cloud cover/shading or line stripping of Landsat 7. The sensing period of the selected images was between the 1st of August and 16th of September. This particular time window was selected because it corresponds to the driest period in the study area where annual herbaceous vegetation has died out. Since the study focuses on the densening of woody vegetation the absence of live herbaceous vegetation is expected to aid the analysis which is based on vegetation indices. All images were obtained pre-processed at level 2A (geometrically and atmospherically corrected to BoA reflectance) by the EROS cen-ter. These images, provided by the Landsat program, apart from being geometrically and atmospherically corrected, they have a radiometric resolution of 16-bit which makes it easier to compare between the three sensors.

The Landsat series provides earth observation data since 1972 at varying spectral and spatial resolutions (Table 2). Since 1982, when Landsat 4 was launched, the spatial resolution is stable at 30m for the multispectral products. Due to the long time span of Landsat data availability they are quite extensively used to build time series datasets for long term monitoring of vegetation dynamics [14-19]. The Thermal and Coastal/Aerosol bands were excluded from the analysis as well as the panchromatic image.

Table 1. Satellite Images used in the study

	LANDSAT IMAGE	DATE
1	LT05_L2SP_185032_19840717_20200918_02_T1	17_07_1984
2	LT05_L2SP_185032_19850906_20200918_02_T1	06_09_1985
3	LT05_L2SP_185032_19860824_20200918_02_T1	24_08_1986
4	LT05_L2SP_185032_19870811_20201014_02_T1	11_08_1987
5	LT05_L2SP_185032_19880829_20200917_02_T1	29_08_1988
6	LT05_L2SP_185032_19890731_20200916_02_T1	31_07_1989
7	LT05_L2SP_185032_19900819_20200915_02_T1	19_08_1990
8	LT05_L2SP_185032_19910721_20200915_02_T1	21_07_1991
9	LT05_L2SP_185032_19920909_20200914_02_T1	09_09_1992
10	LT05_L2SP_185032_19930827_20200913_02_T1	27_08_1993
11	LT05_L2SP_185032_19940814_20200913_02_T1	14_08_1994
12	LT05_L2SP_185032_19950902_20200912_02_T1	02_09_1995
13	LT05_L2SP_185032_19960803_20200911_02_T1	03_08_1996
14	LT05_L2SP_185032_19970721_20200910_02_T1	21_07_1997
15	LT05_L2SP_185032_19980825_20211205_02_T1	25_08_1998
16	LT05_L2SP_185032_19990812_20200918_02_T1	12_08_1999
17	LT05_L2SP_185032_20000729_20200907_02_T1	29_07_2000
18	LT05_L2SP_185032_20010716_20200905_02_T1	16_07_2001
19	LE07_L2SP_185032_20020711_20200916_02_T1	11_07_2002
20	LT05_L2SP_185032_20030722_20200905_02_T1	22_07_2003
21	LT05_L2SP_185032_20040910_20200903_02_T1	10_09_2004
22	LT05_L2SP_185032_20050719_20200914_02_T1	19_07_2005
23	LT05_L2SP_185032_20060908_20200914_02_T1	08_09_2006

24	LT05_L2SP_185032_20070717_20200830_02_T1	17_07_2007
25	LT05_L2SP_185032_20080812_20200913_02_T1	12_08_2008
26	LT05_L2SP_185032_20090714_20200911_02_T1	14_07_2009
27	LT05_L2SP_185032_20100818_20200910_02_T1	18_08_2010
28	LT05_L2SP_185032_20110829_20200820_02_T1	29_08_2011
29		
30	LC08_L2SP_185032_20130919_20200912_02_T1	19_09_2013
31	LC08_L2SP_185032_20140704_20200912_02_T1	04_07_2014
32	LC08_L2SP_185032_20150723_20200912_02_T1	23_07_2015
33	LC08_L2SP_185032_20160709_20200912_02_T1	09_07_2016
34	LC08_L2SP_185032_20170712_20200912_02_T1	12_07_2017
35	LC08_L2SP_185032_20180715_20200912_02_T1	15_07_2018
36	LC08_L2SP_185032_20190819_20200912_02_T1	19_08_2019
37	LC08_L2SP_185032_20200906_20200912_02_T1	06_09_2020
38	LC08_L2SP_185032_20210808_20200912_02_T1	08_08_2021
39	LC09_L2SP_185032_20220819_20200912_02_T1	19_08_2022

Bands (wavelength μm) - Spatial Resolution		
Landsat 5-TM	**Landsat 7-ETM**	**Landsat 8-OLI**
		B1-Coastal/Aerosol (0.435-0.451) – 30m
B1-Blue (0.45-0.52) – 30m	B1-Blue (0.441-0.514) – 30m	B2-Blue (0.452-0.512) – 30m
B2-Green (0.52-0.60) – 30m	B2-Green (0.519-0.601) – 30m	B3-Green (0.533-0.590) – 30m
B3- Red (0.63-0.69) – 30m	B3- Red (0.631-0.692) – 30m	B4- Red (0.636-0.673) – 30m
B4-NIR (0.76-0.90) – 30m	B4-NIR (0.772-0.898) – 30m	B5-NIR (0.851-0.879) – 30m
B5-SWIR 1 (1.55-1.75) -30m	B5-SWIR 1 (1.547-1.749) – 30m	B6-SWIR 1 (1.566-1.651) – 30m
B7-SWIR 2 (2.08-2.35) – 30m	B7-SWIR 2 (2.064-2.345) – 30m	B7-SWIR 2 (2.107-2.294) – 30m
B6 –TIR (10.40-12.50) – 120m	B6 –TIR (10.31-12.36) – 60m	B10-TIR 1 (10.60-11.19) – 30m B11-TIR 2 (11.50-12.51) – 30m
		B9-Cirrus (1.363-1.384) – 30m
	B8-Pan (0.515-0.896) – 15m	B8-Pan (0.503-0.676) – 15m

Table 2. Spectral and Spatial characteristics of the Landsat images used in this study

2.2.10. Remote sensing data analysis

Vegetation Indices (VI's) were employed to monitor the vegetation trends and forest densening in the study area. Recording and monitoring vegetation changes using Vegetation Indices is a relatively fast process that allows a good understanding of changes in space and time. In the current study five VI's were used, which were selected based on their capability to capture vegetation variation in an image, as it is documented in the literature. The specific properties of each of the employed vegetation indices are provided in the following paragraphs. The five indices were the Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), Enhanced Vegetation Index 2 (EVI2), Normal-ized Difference Water Index (NDWI) and Bare Soil Index (BSI; Table 3).

Table 3. Vegetation Indices and Spectral Ratios employed in the study.

Vegetation Index	Formula	Reference
NDVI	((NIR-RED))/((NIR+RED))	[21]
SAVI	((NIR-RED))/((NIR+RED+0.5))* (1+0.5)	[22]
EVI2	2,5 *((NIR-RED))/((NIR+2.4*RED+1))	[23]
NDWI	((NIR-SWIR))/((NIR+SWIR))	[24]
BSI	((SWIR2+RED)-(NIR+BLUE))/((SWIR2+RED)+(NIR+BLUE))	[25]

NDVI is one of the vegetation indices that combines the two opposite properties of canopy. It is known that the spectral profiles from green vegetation represent two spe-cific areas where the highest discrepancy occurs (red to nir region)[21]. Because of this property, NDVI is considered an appropriate vegetation index to study vegetation patterns across temporal or spatial scales and it has been extensively used in such studies [26-29]. SAVI is based on the original NDVI formula and it is a transformation technique to minimize the effect of soil brightness. It has been found to give better re-sults than NDVI in cases of high variation in soil color and moisture [22]. EVI was de-veloped to optimize the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a decoupling of the canopy background signal and a reduction in atmosphere influences [23]. NDWI [24] is an index derived from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) channels. The SWIR reflects variation in both the vegetation water content and the spongy mesophyll structure in vegetation canopies, while the NIR reflectance is affected by leaf internal structure and leaf dry matter content but not by water content. The combination of the NIR with the SWIR removes variations induced by leaf internal structure and leaf dry matter content, improving the accuracy in retrieving the vegetation water content [30]. Bare Soil Index (BSI) is a numerical indicator that combines blue, red, near infrared and short wave infrared spectral bands to capture soil variations. These spectral bands are used in a normalized manner. The short wave infrared and the red spectral bands are used to quantify the soil mineral composition, while the blue and the near infrared spectral bands are used to enhance the presence of vegetation. The original BSI [31] used SWIR1 reflectance, but recent research by Diek et al. [25] suggests the SWIR2 band may be more appropriate for calculating BSI. For this reason, the SWIR2 band was used in this study to calculate BSI index.

One thousand points were randomly located across the entire study area, using the Sampling Design Tool, available as a plugin in ArcMap 10.8, and they formed the basis for the determination of vegetation dynamics across the time span of the study. The vegetation index values of the pixel corresponding to each particular point are then assigned as attributes to the point. Linear regression was employed to test for significant relationships between the tested vegetation indices and time.

3 Results

The tested vegetation indices show all statistically significant relationships with time and statistically significant positive or negative trends during the study period (Table 4). The results clearly indicate that during the study period the vegetation cover of the study area has increased significantly.

Table 4. Results of the linear regression between time and vegetation indices

Vegetation Indices	Linear Regression		
	b	Adj-R^2	p
NDVI	0.0021	0.56	<0.001
SAVI	0.0032	0.55	<0.001
EVI2	0.0042	0.55	<0.001
NDWI	0.0018	0.66	<0.001
BSI	-0.0014	0.60	<0.001

All indices which are sensitive to the existence of vegetation exhibit a positive trend during the study period (Figures 1-4), while the BSI, which is sensitive to bare ground exhibit a negative trend (Figure 5). BSI is an index which constitutes a combi-nation between a vegetation index and a bare soil index and tends to obtain higher values in the least vegetated areas[37]. Both these results demonstrate that vegetation has increased its density significantly during the study period, as a result of several factors that will be discussed later.

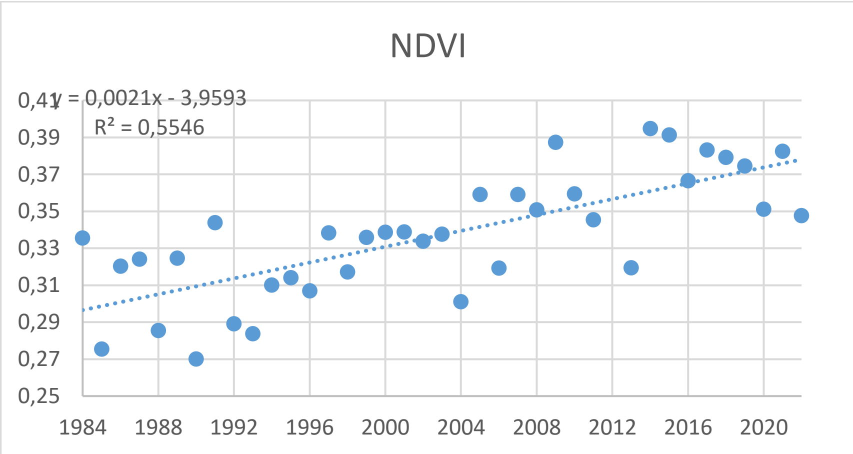

Figure 1. NDVI dynamics and trend during the study period. The graph is built based on the 1000 randomly located points, corresponding to 1000 pixels.

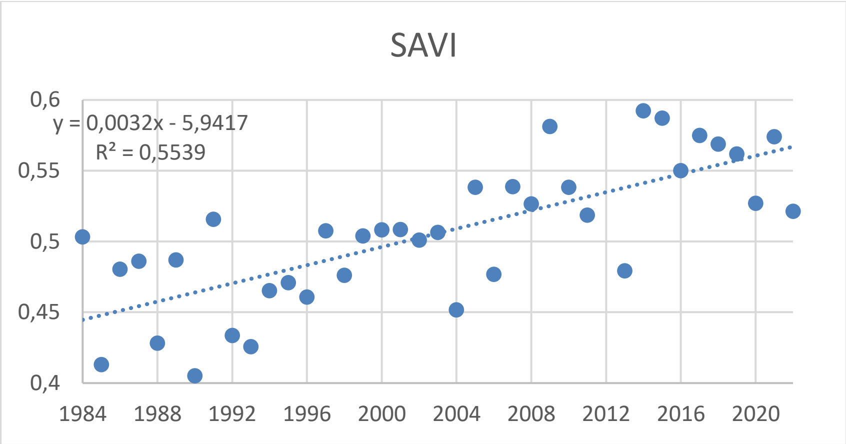

Figure 2. SAVI dynamics and trend during the study period. The graph is built based on the 1000 randomly located points, corresponding to 1000 pixels.

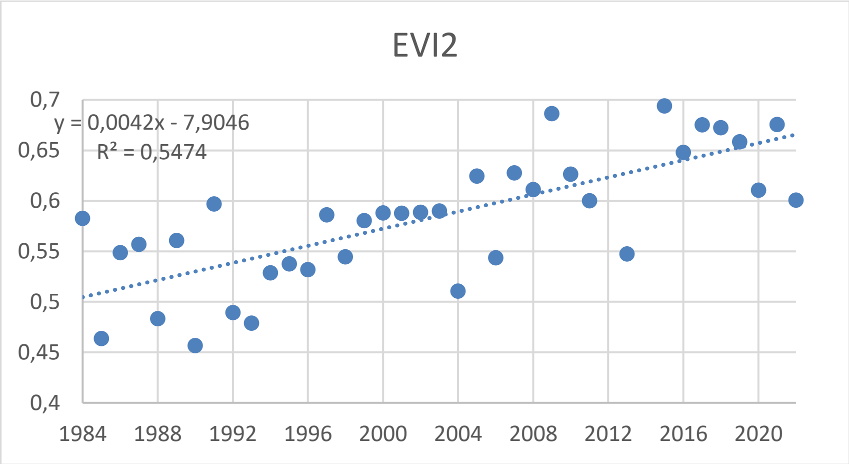

Figure 3. EVI dynamics and trend during the study period. The graph is built based on the 1000 randomly located points, corresponding to 1000 pixels.

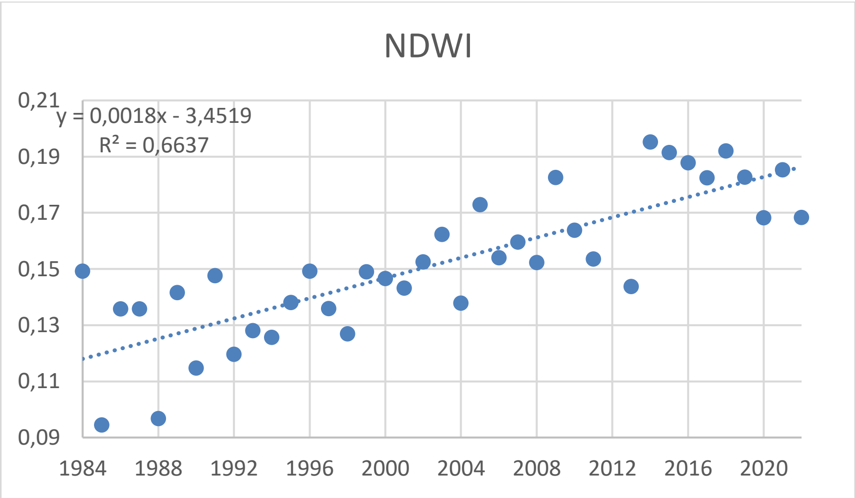

Figure 4. NDWI dynamics and trend during the study period. The graph is built based on the 1000 randomly located points, corresponding to 1000 pixels.

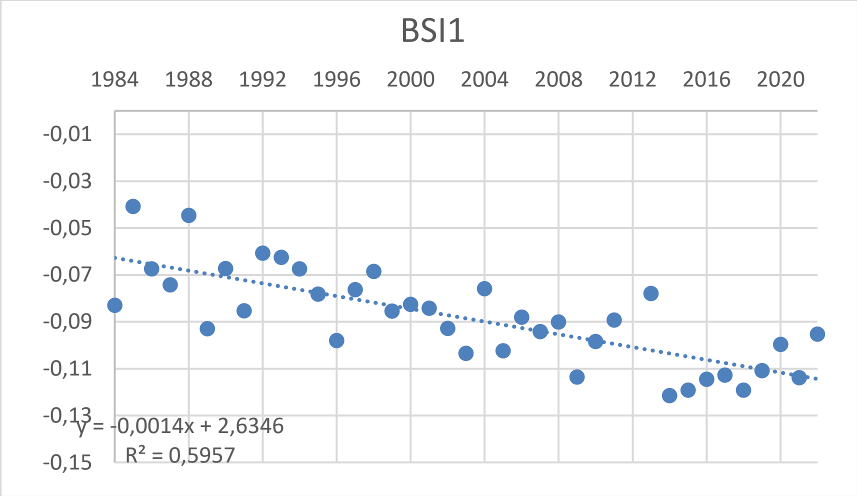

Figure 5. BSI dynamics and trend during the study period. The graph is built based on the 1000 randomly located points, corresponding to 1000 pixels.

Figures 6 shows a visual representation of the of the NDVI trend over the study period and it clear show that areas with high NDVI value are increasing while those with low are decreasing.

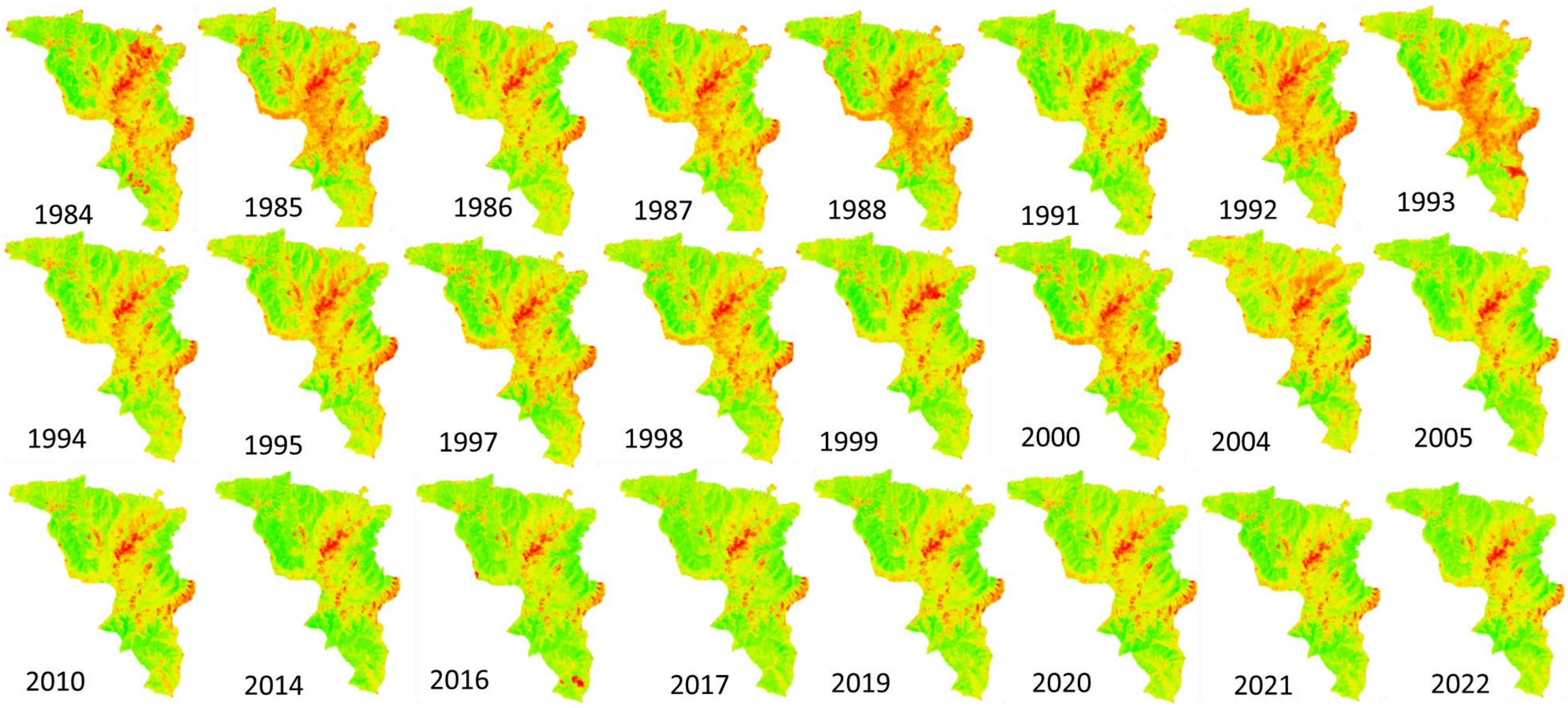

Figure 6. NDVI trend over the study period.

4 Conclusions and recommendations

Pelister National Park appear to represent a dynamic landscape with significant vegetation transitions occurring during the recent decades, probably as a result of land abandonment, reduction of livestock breeding and climate change. This transition is likely to altitudinally increase the tree line allowing the Balkan pine to advance in higher altitudes and reduce the area currently cover by sub-alpine grasslands (Figure 7). At the same time the same drivers are likely restrict in the future the area covered currently by Balkan pine due to encroachment by the more competitive species *Abies alba* which is already present in various parts of the study area.

Figure 7. Expansion of Balkan pine into higher altitudes and subalpine grasslands

An important consequence of land abandonment and forest recovery is the increase of biomass, which on one hand is a positive service, due to higher concentration of carbon, but on the other hand it increases the amount and continuity of fuel [32]. This trend has been observed in several other areas with similar vegetation dynamics and as a result the relative importance of weather patterns and fuel in determining fire regime and behavior has shifted in recent years in favor of the former and fires have turned from “fuel-driven” to “weather-driven” [33-36]. This simply means that when whether conditions are suitable for a wildfire to start and progress then it is likely to turn into an intensive fire because fuel availability is ensured. Furthermore Konoes et al. [37] reported an increase in the altitudinal range that fires occur in recent years demonstrating the increased risk of forest fires in non-fire prone environments where species are not adapted to frequent fires. Similar observation was made by Xofis & Poirazidis [38] for another protected area in Norhern Greece which indicates the increased susceptibility of mountainous areas to wildfires.

The climatic trends of the study area are also a reason for concern regarding the fire dynamics. Although the data presented in figures 8 are the result of spatial interpolation of the weather observations made in meteorogical stations within a radius of the study area and they have to be treated with care, it is pretty obvious that there is a trend of increased mean annual temperature in the last 40 years. This observation in combination with the reported above increase in the biomass concentration may lead to the conclusion that wild fires are likely to increase in frequency in Pelister NP which makes the adoption of fire prevention measures increasingly necessary.

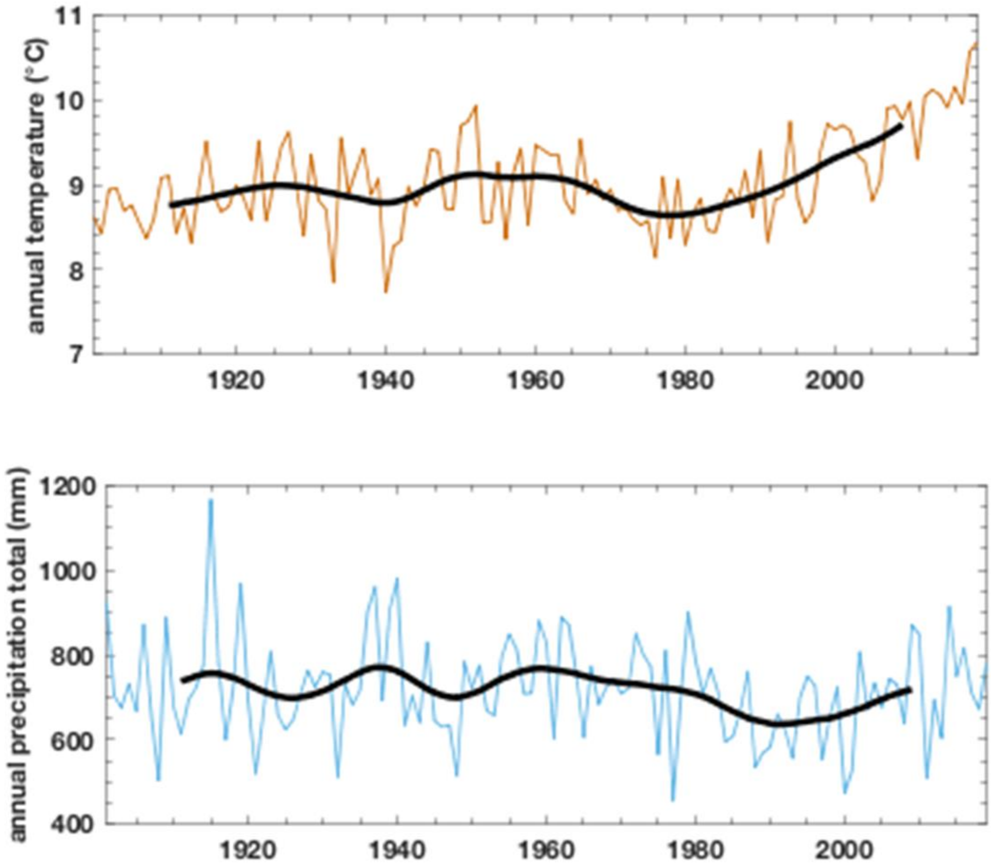

Figure 8. Mean annual temperature and precipitation trend in the study area [39]

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